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NASA-Ames University Consortium Joint Research Interchange

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**EXPERIMENTAL INVESTIGATION OF ORGANIC SYNTHESIS  
IN HYDROTHERMAL ENVIRONMENTS**

Summary of Research for the period:

1 November 1997 through 31 October 1998

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The research proposed for this joint research interchange was conducted at NASA's Ames Research Center in Moffett Field, CA and at the U. S. Geological Survey in Menlo Park, CA. The primary purpose of the interchange was to allow Dr. Mitchell Schulte, a Washington University graduate, to perform postdoctoral research. Coming into the postdoctoral position primarily as a theoretician, Dr. Schulte spent a great deal of time learning to conduct experiments complementary to his previous theoretical research in determining the synthesis and stability of aqueous organic compounds under hydrothermal conditions. He also was instructed in the use of analytical instrumentation, including derivatization of reaction products and analysis by gas chromatography-mass spectrometry.

During the course of the experimental work, Dr. Schulte and colleagues demonstrated that experimental mineral buffers are effective at relatively low temperatures (250°C) and that oxidation state has a major influence on the stability of organic compounds in hydrothermal environments. The oxidation state of such systems is primarily a function of the composition of the host rocks, and the difference in oxidation state for different mineral buffers was explored. In addition, it appears that mineral surfaces may play a role as catalysts in aqueous organic reactions. Catalysts cannot be unaccounted for in standard geochemical models, demonstrating the need to couple theoretical and experimental research efforts.

Specifically, preliminary results from the experiments demonstrate that amino acids are highly reactive at hydrothermal conditions, and that the products of the decomposition of amino acids are predictable. The products of decomposition of four amino acids studied were ammonia, CO<sub>2</sub> and carboxylic acids. The system, again according to prediction, appeared to reach a steady state, which may be considered a metastable state, in which organic compound concentrations maintained relatively constant ratios.

The supercritical water oxidizer (SCWO) at NASA Ames, previously used to study the conversion of organic material to harmless or useful products such as CO<sub>2</sub> and water, was restored to functionality and now can be used to try to synthesize organic compounds. Due to the lengthy nature of the restoration process, work on the SCWO had only progressed to the testing stage at the termination of the research period. Initial tests are encouraging, and the experimental work using this apparatus is continuing on a no-cost to this program basis.

The initial results described above were presented at the 1st NASA Astrobiology Institute General Meeting held at NASA Ames Research Center from 5-7 November 1998 in the form of a poster and acknowledged the support of this grant. The abstract of this presentation is included below.

#### Abstract

Seafloor hydrothermal systems may be the most likely locations on the early Earth for the emergence of life. Because of the disequilibrium inherent in such dynamic, mixing environments, abundant chemical energy would have been available for formation of the building blocks of life. In addition, theoretical studies suggest that organic compounds in these conditions would reach metastable states, due to kinetic barriers to the formation of stable equilibrium products (CO<sub>2</sub> and methane). The speciation of organic carbon in metastable states is highly dependent on the oxidation state, pH, temperature, pressure and bulk composition of the system. The goal of our research is to investigate the effects of a number external variables on the formation, transformation, and stability of organic compounds at hydrothermal conditions.

We have begun experimental work to attempt to control the oxidation state of simulated hydrothermal systems by using buffers composed of mineral powders and gas mixtures. We are also beginning to test the stability of organic compounds under these conditions. The experiments are being performed using the hydrothermal bomb apparatus at the U.S. Geological Survey in

Menlo Park, CA and the supercritical water oxidizer (SCWO) at NASA Ames Research Center in Moffett Field, CA.

The amino acids decomposed rapidly. Even after the approximately 15 minutes between addition of the amino acids and the first sampling, no amino acids were detected in the PPM system by GC-MS, while in the FeFeO system the amino acids were present at a level of less than 50% of original. Carboxylic acids, ammonia, and CO<sub>2</sub> were the main products, along with some unidentified compounds. The ratios of carboxylic acids and concentrations of other products seem to have remained stable during the experiments, consistent with observations of other metastable systems and theoretical predictions.